Leonardo Labs
Quantum Technologies Lab

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AI-enhanced Non-Line of Sight Imaging

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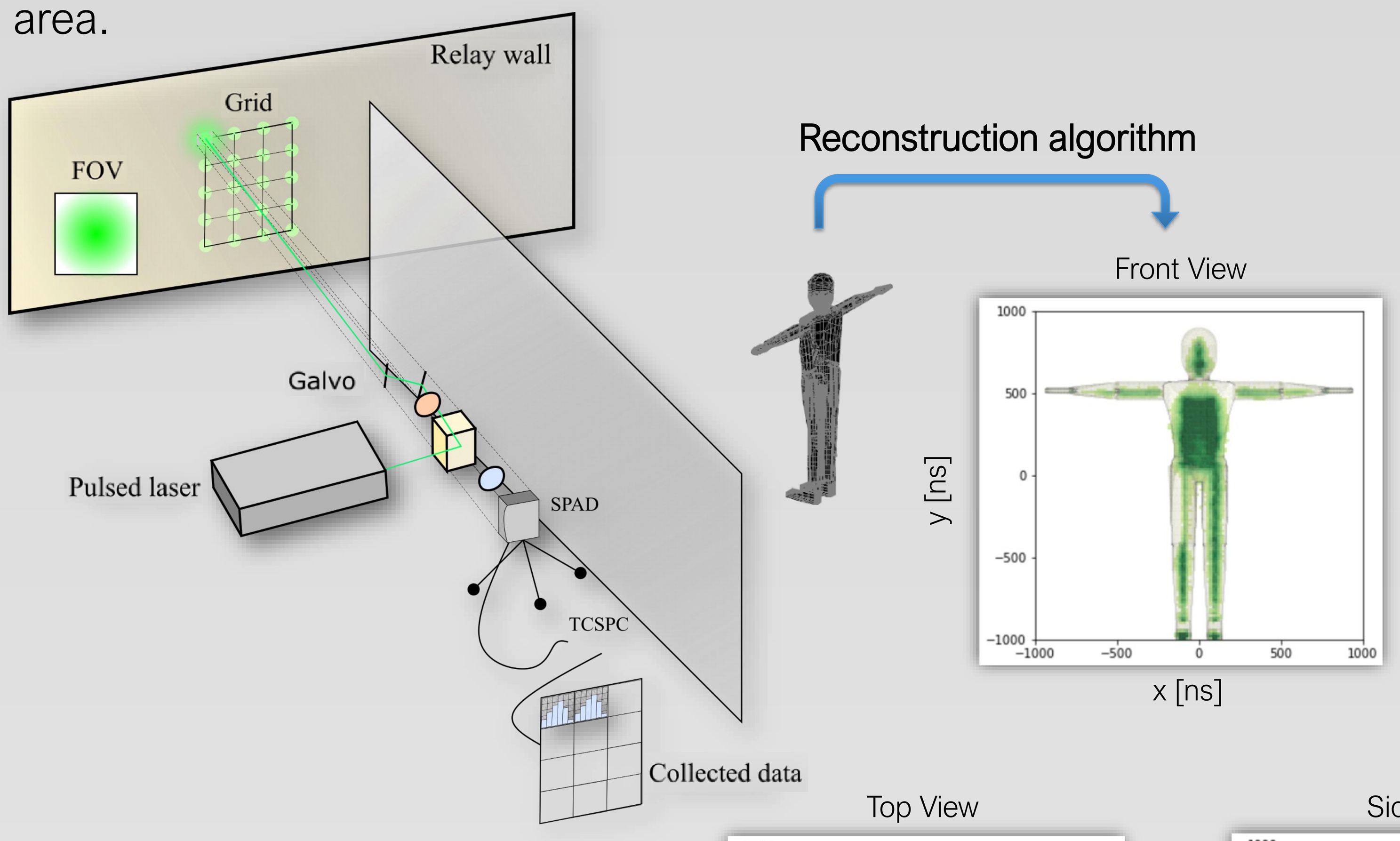
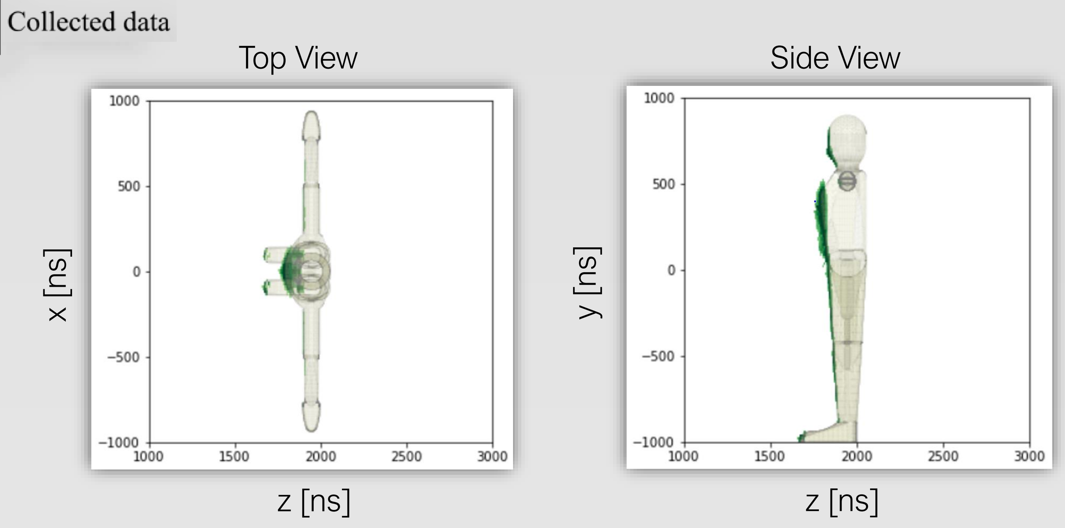
INTRODUCTION

Non-line-of-sight (NLOS) imaging has demonstrated[1] to overtake the restrictions of modern 3D active imaging systems that relay on the direct line of sight of the transceiver unit and the target.

In this sense, the presence of an eventual occluder in the scene is circumvented through te proposed single-photon technique, where pulsed light is initially directed to an intermerdiate scattering wall (relay wall), in order to probe the entire hidden area.



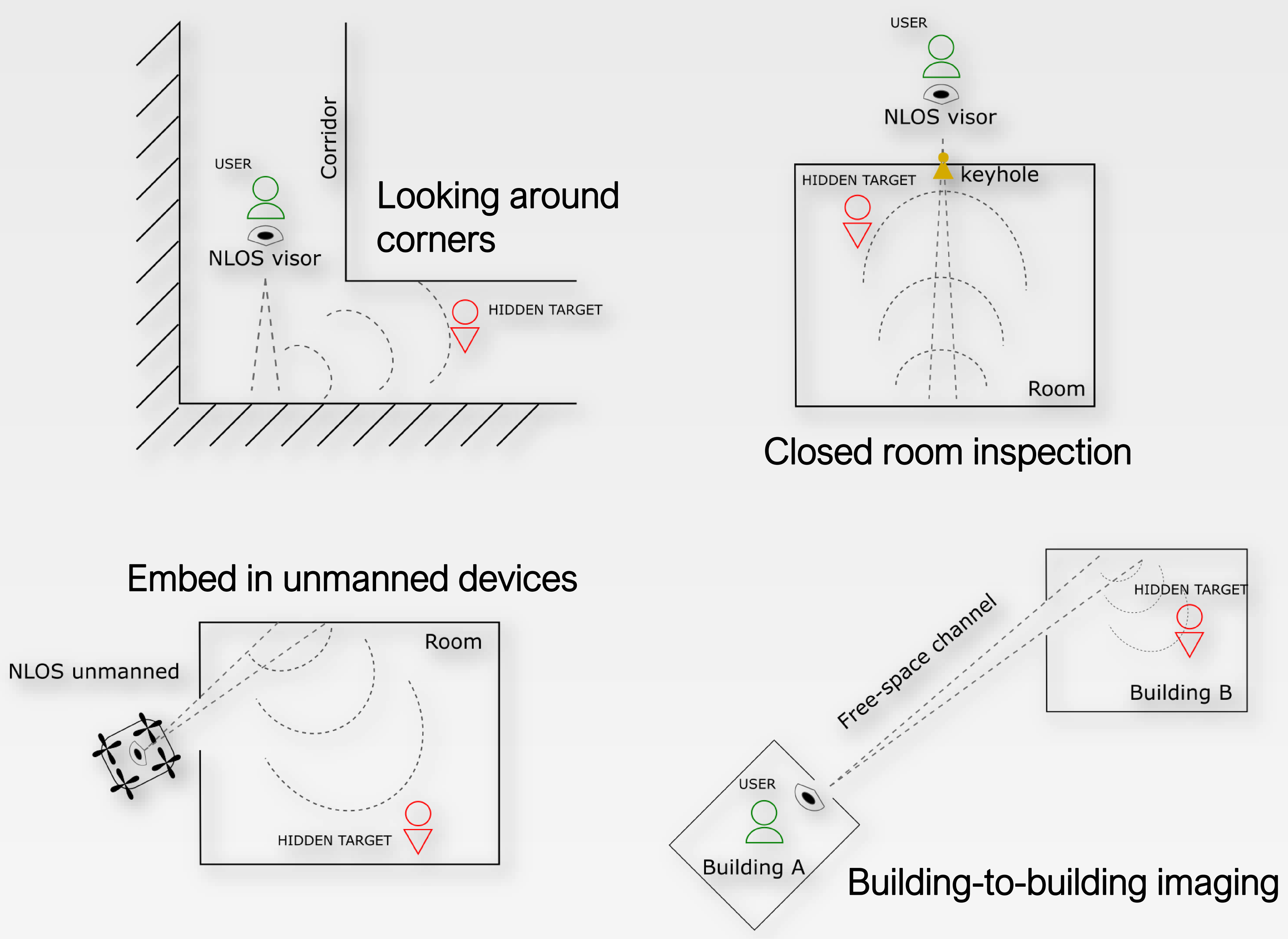
After a three-bounce multiscattering process, just few photons are back propagated and are timestamped with a fast gated single-photon detector.



A 3D temporal histogram tensor (called transient image) is obtained by raster scanning calibrated grids of different sizes on the relay wall. Finally, a back-propagation alghoritm is used to reveal the 3D shape and visual appearance of the unknown scene.

APPLICATIONS

NLOS imaging promises to be a disruptive technology in many defence and security scenarios of interest for Leonardo.



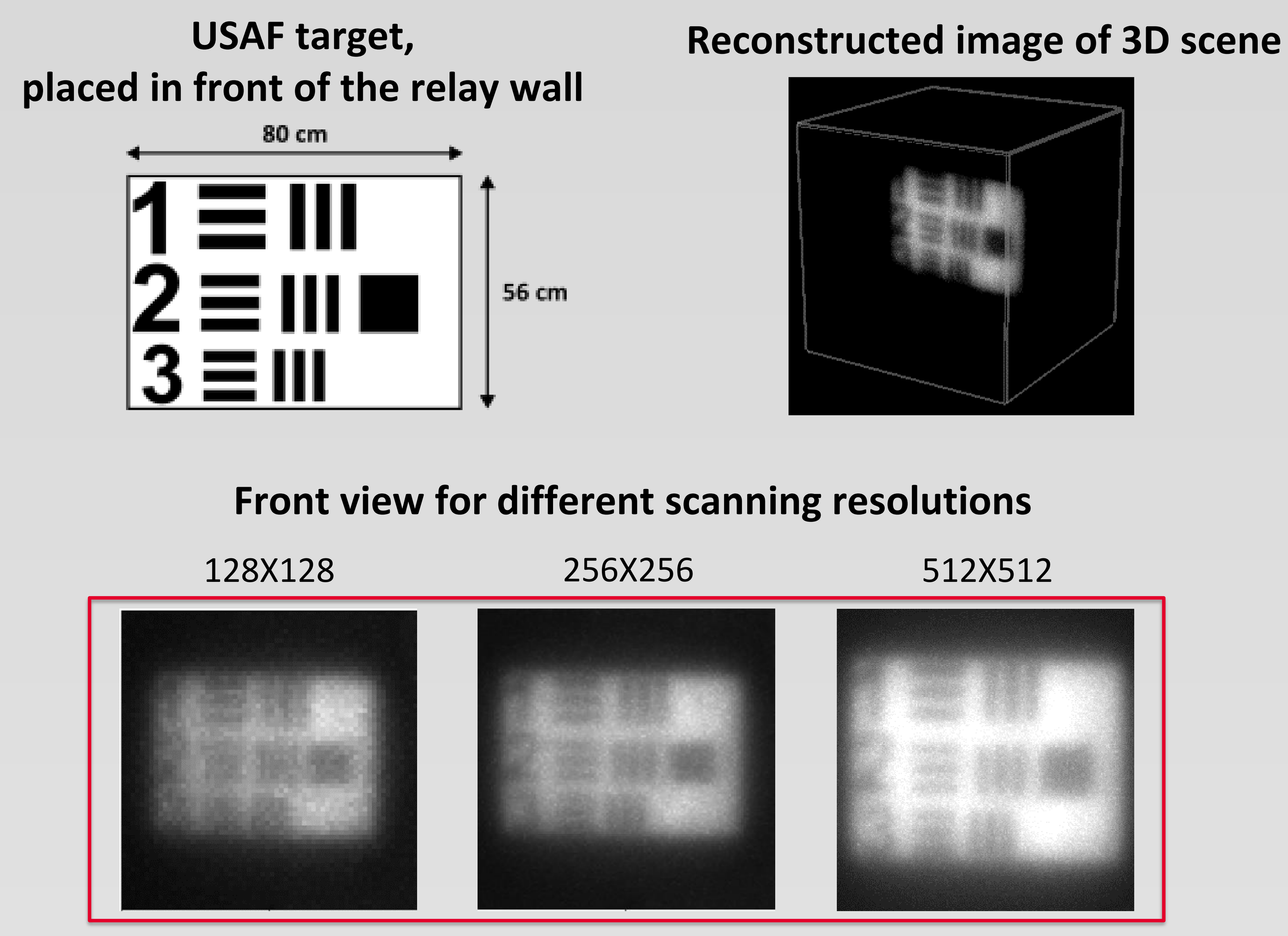
REFERENCES

[1] Velten, A. et al., "Recovering three-dimensional shape around a corner using ultrafast time-of-flight imaging", Nat. Comm. 3, (2012).

[2] Liu X, et al., "Analysis of Feature Visibility in Non-Line-of-Sight Measurement", IEEE/CVF, (2019).

EXPERIMENTAL RESULTS

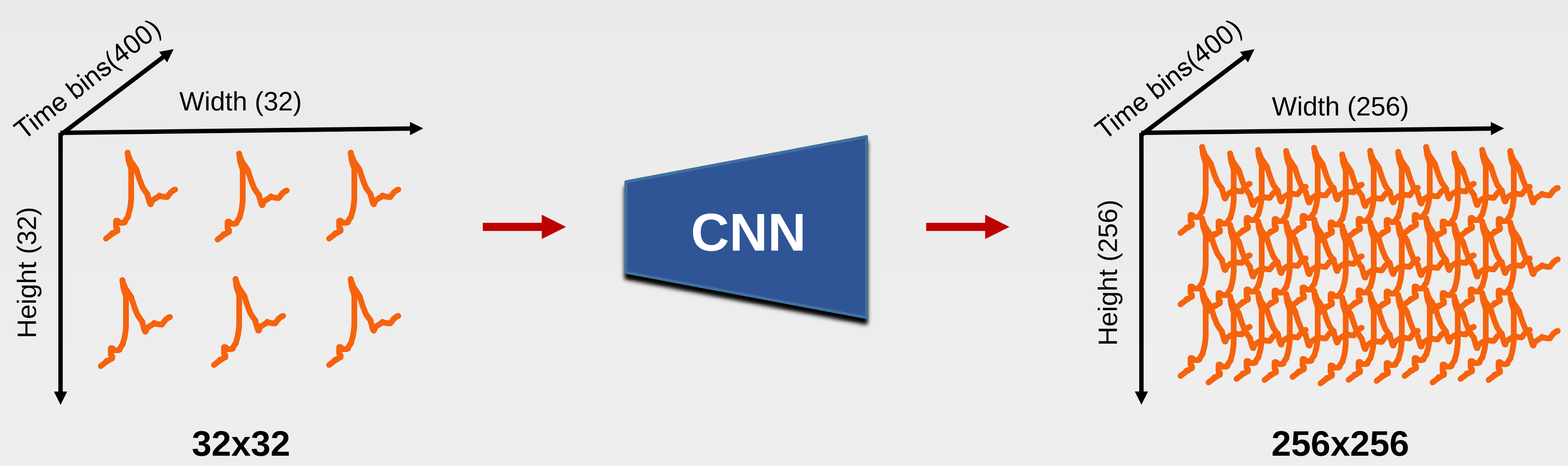
Of all the existing reconstruction algorithms, f-k migration technique was selected benchmarking its performance against a known target for different raster scanning resolutions.



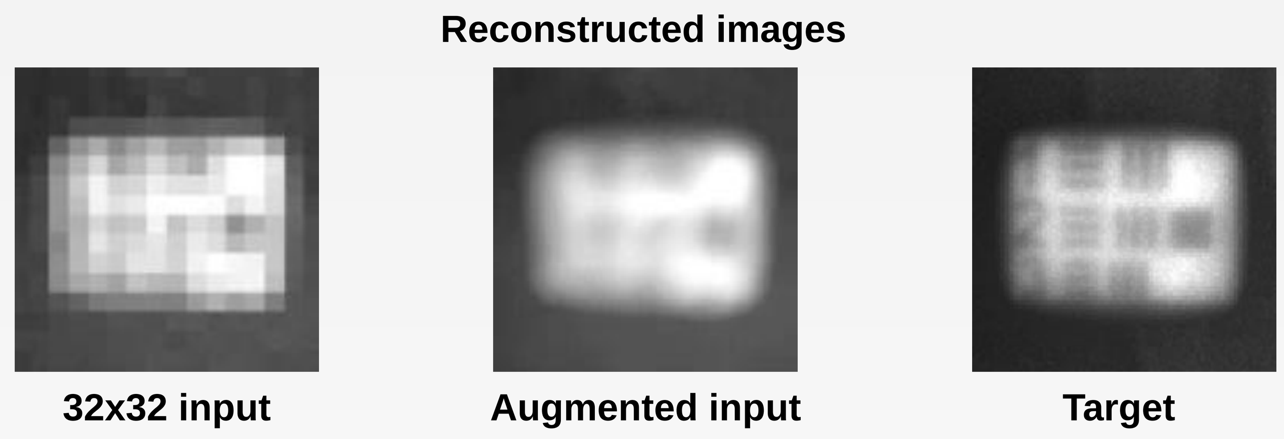
The reconstruction method can also be used to take a 4Hz clip of a moving target.

AI APPLIED TO NON-LINE-OF-SIGHT IMAGING

A significant challenge with our current methodology is the extensive acquisition time needed for capturing transient images at high scanning resolutions. To address this, we propose an innovative solution: leveraging a Convolutional Neural Network (CNN) to enhance image resolution efficiently. Instead of directly acquiring high-resolution images, we initially capture images at a lower resolution (for instance, 32x32). This low-resolution image is then fed into the CNN, which elevates its resolution to a finer scale (e.g., 256x256). Following this upscaling, we apply the f-k migration process.



The network includes a series of deconvolutions to increase the resolution of the input transient image. It has been trained on a set of simulated data (specifically bikes) composed by ~3000 256x256 images which are downscaled to obtain the low-resolution/high-resolution pairs. The model is then tested on experimental data (the USAF target). Initial outcomes from this testing phase are promising, indicating the model's potential efficacy in practical applications.



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